Changes in the Aquatic Plant Community of Mason Lake
Adams County
1988-2001
MWBC: 175700

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Executive Summary

Mason Lake is a eutrophic lake with a plant community characterized by average diversity, low quality and abundant growth distributed throughout the entire lake basin.

Mason Lake supports abundant plant growth because of several factors:

1) fertile sediments
2) hard water
3) high nutrient water
4) broad, gradually sloped littoral zone
5) the shallow lake basin.

The early summer plant community is dominated by curly-leaf pondweed, coontail and Eurasian watermilfoil. The curly-leaf pondweed dies off after it reaches its peak in June. Coontail and Eurasian watermilfoil are the late summer dominant species.

Aquatic Plant Management in Mason Lake

Two types of plant management have been conducted on Mason Lake: chemical treatments and winter drawdown. Both methods can adversely impact plant species diversity and increase disturbance within the plant community, but the two exotic species have a greater adverse impact on the plant community.

When compared with selective chemical treatments, winter drawdown had a less severe impact on species diversity and was more successful in controlling both exotic species and opening up areas in the dense vegetation beds. However, winter drawdowns could not have an impact on vegetation in the deeper portions of the lake.

Recommendations

To improve the aquatic community in Mason Lake it is recommended that the lake district:

A) Continue winter drawdowns. This method has been shown to reduce the two exotic plant species in the zone impacted by drawdown and reduce overall plant density in the shallow zone.

B) Do not return to broad-spectrum chemical treatments. The earlier non-selective chemical treatments promoted the spread of the nuisance-causing, non-native plant species. Any future chemical treatments should be conducted to target the two non-native species: Eurasian watermilfoil and curly-leaf pondweed.

C) Start a harvesting program. Design the harvesting plan with two components

a) early season harvesting to remove curly-leaf pondweed before it dies back

b) mid-summer harvesting of lanes to open up boating and fish lanes and reduce the coverage of Eurasian watermilfoil.

D) Encourage lake residents to establish a natural buffer zone of native vegetation around Mason Lake.

E) Preserve and enhance wetlands in the around Mason Lake and in the watershed.

F) Cooperate with educational and other efforts in the watershed

I. INTRODUCTION

Studies of the aquatic plants (macrophytes) in Mason Lake were conducted in 1988, July 1992 and August 1995 by Water Resource Staff of the North-Central District - Department of Natural Resources (DNR). Using the same methods, studies of the aquatic macrophytes were conducted during June and August of 1998 and 1999 and June 2001 by Water Resource staff of the West-Central Region - DNR.

The surveys were part of a Long Term Trend Study involving 50 lakes throughout the state. Aquatic plant data is collected every three years and water quality data every year on these trend lakes. The study in 1999 was conducted on Mason Lake in order to compare the impacts of winter drawdown, with those of a selective aquatic herbicide treatment for Eurasian watermilfoil.

Background & History

Mason Lake is a 855-acre impoundment on the South Branch of Neenah Creek, in Adams County. The maximum depth is 9 feet. The town of Douglas (Marquette County) owns the dam that forms Mason Lake.

Mason Lake has a long history of algae blooms and abundant plant growth. It also has a long history of chemical treatments to reduce plant and algae growth. The first recorded complaints concerning excessive plant growth occurred in 1947 and concerning algae occurred in 1952. Requests for information about chemical treatments for algae and aquatic plants have been ongoing since 1947, but no record of treatment exists before 1972.

Several chemicals have been applied to the lake during the years 1972-2001 (Table 1),

1) 1831 pounds of pure copper (1823 pounds from 7235 pounds of copper sulfate and 8 pounds from 80 gallons of cutrine)
2) 499 gallons of endothall products (128 gallons in the form of the monoamine salt which is more detrimental to young fish). Endotahll products are broad-spectrum contact herbicides that kill all aquatic plant species.
3) 445 gallons of diquat. Diquat products are broad-spectrum contact herbicides that kill all aquatic plant species.

4) 5016 pounds of 2,4-D, a chemical selective for broad-leaf species such as Eurasian watermilfoil.

Table 1. Recorded Chemical Treatments for Aquatic Plants and Algae in Mason Lake.

	$CuSO_4$ (lbs.)	Cutrine (gal.)	Aquathol	Diquat (gal.)	2,4-D
1972	700		50 lbs.	1	
1973	1000		10 gal.	4	
1974	750			9	
1975	550			20	
1976	750			25	
1977	440			40	
1978	625			39	
1979	650		5 gal. H*	42	
1980				46	
1981	250		118gal. H 30 gal.		
1982		15	5 gal. H 30 gal.		
No records of treatment					
1990		1			32 lbs.
1991		10	40 lbs.		30 lbs.
1992	100		17 gal.	14	8 gal.
1993	400		25 gal.	20	
1994			10.5 gal.	7	
1995		20	20 gal.	20	
1996	600		30 gal.	49.5	
1997	420		44 gal.	59	
1998		~50	~50 gal.	~50	
1999			55 gal.		1600 lbs
2000			49.25 gal.		1646 lbs
2001					1700 lbs
Totals	7235 lbs.	80gal.	370.75 gal. 90 lbs (128gal. H)	445gal.	5016 lbs.

* H = Hydrothol formulation of endothall more damaging to young fish

Treatment areas each year have varied, but over the years, nearly the entire littoral zone has been treated, except for the north bay. Four different channels across the lake have been treated.

Winter drawdowns have also been used to control aquatic plants. The first permit for a drawdown was applied for in 1988; it was a two-year permit. Subsequent permits for winter drawdown have been approved (Table 2). Winter drawdowns were conducted annually from 1988-1995. There was a discontinuation of winter drawdowns for three years (1995-1998) and resumption of winter drawdowns in 1998 (Table 2).

Table 2. Winter Drawdowns on Mason Lake

	Winter	**Depth of Drawdown**
Two-year Permit	1988-1989	5 Feet
	1989-90	4 Feet
Five-year Permit	1990-91	4 Feet
	1991-92	4 Feet
	1992-93	4 Feet
	1993-94	4 Feet
	1994-95	4 Feet
Two-year Permit	1998-99	1.5 Feet
	1999-2000	1.5 Feet
Five-year Permit	2000-2001	1.5 Feet
	2001-2002	3.0 Feet

(Scott Ironside pers. comm.)

In 1999, the chemical treatments were not conducted in the zone impacted by the drawdown so that impacts of the separate management techniques could be compared.

II. METHODS

Field Methods

The same study design was used for the 1992, 1995, 1998, 1999 and 2001 macrophyte studies and was based primarily on the rake-sampling method developed by Jessen and Lound (1962). Twenty-six equal-distance transect lines were placed perpendicular to the shoreline with the first transect being randomly placed. These transects were mapped to be used in all aquatic plant surveys (Appendices).

One sampling site was randomly located in each depth zone (0-1.5ft., 1.5-5ft., and 5-10ft.) along each transect. Using a long-handled thatching rake, four rake samples were taken at each sampling site. The four samples were taken at each quarter of a 6-foot square quadrat. The aquatic plant species that were present on each rake sample were recorded.

Each species was given a density rating (0-5) based on the number of rake samples at each sampling site on which it was present.
A rating of 1 for each species present on one rake sample;
A rating of 2 for each species present on two rake samples;
A rating of 3 for each species present on three rake samples;
A rating of 4 for each species present on four rake samples;
A rating of 5 indicates that a species was abundant on all rake samples at that sampling site.)

The species recorded include aquatic vascular plants and several types of algae that have morphologies similar to vascular plants, such as muskgrass and nitella.

The presence of filamentous algae was recorded.

The sediment type at each sampling site was recorded.

The type of shoreline cover was recorded at each transect. A section of shoreline, 50 feet on either side of the transect intercept with the shore and 30 feet back from the shore was evaluated. The percentage of each cover type within this 100 ft. X 30 ft. rectangle was verified by a second researcher and recorded.

Visual inspection and periodic samples were taken between transect lines in order to record the presence of any species that did not occur at the sampling sites. Specimens of all plants present were collected and saved in a cooler for later preparation of voucher specimens. Nomenclature was according to Gleason and Cronquist (1991).

Data Analysis

The frequency and density data for each year was analyzed separately. The data for 1998 and 1999 were separated into sites at water depths of 3 feet or less and sites at water depths greater than 3 feet. This was done to compare the separate effects of the winter drawdown (which would impact vegetation at depths of 3 feet or less) and aquatic herbicide treatments (which was conducted at depths greater than 3 feet.

The percent frequency of occurrence of each species was calculated (number of sampling sites at which it occurred/total number of sampling sites) (Appendices I-X). Relative frequency was calculated based on the number of occurrences of a species relative to all species occurrences (Appendices I-X).

The mean density was calculated for each species (sum of a species' density ratings/number of sampling sites) (Appendices XI-XX). Relative density was calculated based on the density rating of a species relative to all plant densities (Appendices XI-XX). A mean density where present was calculated for each species (sum of a species' density ratings/number of sampling sites at which it occurred) (Appendices XI-XX). The relative frequency and relative density were summed to obtain a Dominance Value (Appendices XXI-XXVI).

Simpson's Diversity Indices (1-sum(relative frequencies)^2) were calculated for each sampling year (Appendices I-X). Each sampling year was compared by a Coefficient of Community Similarity.

III. RESULTS

PHYSICAL DATA

Many physical parameters impact the macrophyte community. Water quality (nutrient levels, algal levels, clarity, pH, hardness) can influence the macrophyte community as the macrophyte community can in turn modify these parameters. Lake morphology, sediment composition and shore land use also effect the macrophyte community.

Water Quality - The trophic state of a lake is an indication of its water quality. Phosphorus concentration, chlorophyll concentration, and water clarity data are collected to determine the trophic state.
Oligotrophic lakes are low in nutrients and support limited plant growth and smaller fish populations.
Eutrophic lakes are high in nutrients and therefore support a large biomass.
Mesotrophic lakes have intermediate levels of nutrients and biomass.
Water quality monitoring has been conducted by both the DNR and Adams County Land Conservation staff.

Nutrients

Phosphorus is a limiting nutrient in many Wisconsin lakes and is measured as an indication of the nutrient concentration in a lake. Increases in phosphorus in a lake can feed algae blooms and, occasionally, excess plant growth. Phosphorus concentrations in Mason Lake have varied, but have remained in the eutrophic range during 1986-2001 (Figure 1). The lowest phosphorus levels were during 1991-1993 and in 1998. Phosphorus has increased in Mason Lake since 1986 (Figure 1).

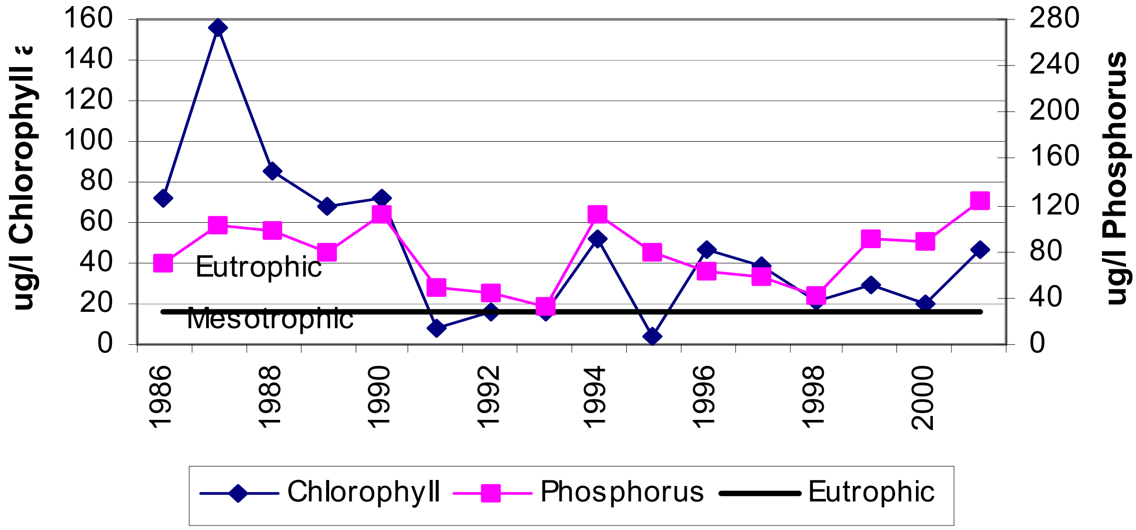


Figure 1. Summer Mean phosphorus and chlorophyll in Mason Lake, 1986-2001.

Algae

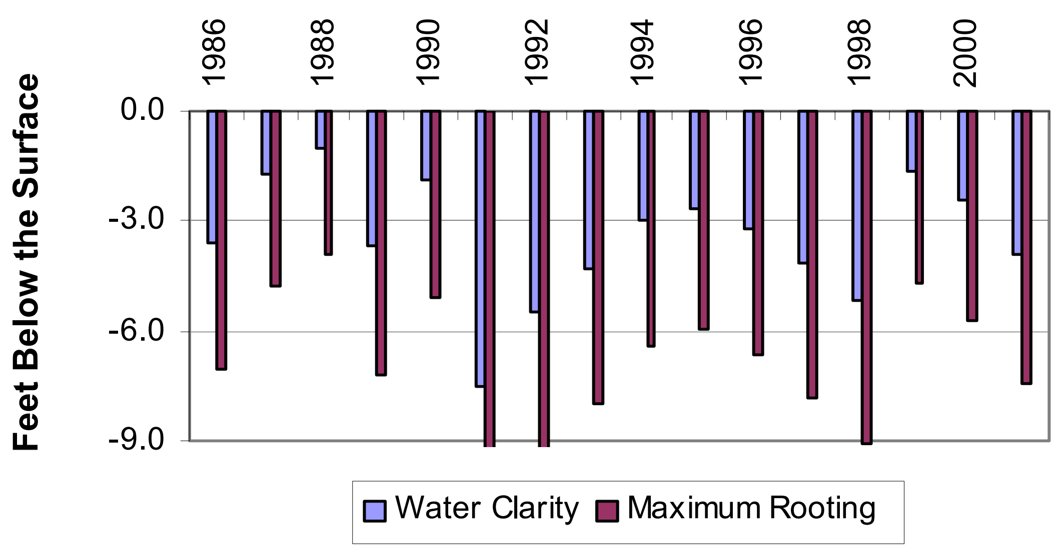
Measuring chlorophyll in a lake indicates algae concentrations. Algae is natural and essential in the lake ecosystem, but high algae concentrations decrease water clarity and reduce light availability for aquatic plant growth.

In Mason Lake, chlorophyll concentrations have also remained in the eutrophic range. The rise and fall of chlorophyll concentrations have followed the change in phosphorus levels as the algae used the available nutrients to reproduce (Figure 1). The variations in chlorophyll concentrations were more extreme than variations in phosphorus concentrations. Other factors such as weather conditions and temperature will influence algae growth. There was an extremely high spike in chlorophyll in 1987; the lowest concentrations of chlorophyll were recorded in 1991-93 and 1995. Chlorophyll has decreased since 1986 (Figure 1).

Water clarity

Water clarity is a critical factor for plant growth. When plants receive less than 1-2% of the surface illumination, they can not survive. Water clarity is reduced by suspended materials such as algae and silt and dissolved organic chemicals that color the water. Water clarity is measured with a Secchi Disc that shows the combined effect of color and suspended materials.

Mean summer water clarity in Mason Lake has ranged from less than 2 feet in 1987 and 1990 to 7 feet in 1991 (Figure 2). This reflects, alternately, the higher nutrients and algae in 1987-1990 and the lower nutrients and algae in 1991. The water clarity in Mason Lake indicates a mesotrophic/eutrophic lake with



poor water clarity.

Figure 2. Water clarity and maximum rooting depth in Mason Lake.

The predicted maximum rooting depth can be calculated from the Secchi Disc water clarity. The predicted maximum rooting depth varies with the water clarity, but in most years would extend to nearly the deepest part of the lake (Figure 2).

Hardness

Hardness in Mason Lake varied between 135-180mg$CaCO_3$/l. Water in the range of 121-180mg$CaCO_3$/l is considered hard. Hard water lakes have a low sensitivity to acid rain and tend to have more plant growth.

Lake Morphometry

The morphometry of a lake is an important factor in analyzing the distribution of aquatic macrophytes. Duarte and Kalff (1986) found that the slope of the littoral zone accounted for 72% of the observed variability in the growth of submergent vegetation. Gentle slopes support a broader zone of potential plant growth than steep slopes. The littoral zone is gradually sloped in Mason Lake and the shallow basin provides light availability to nearly the entire lake.

Sediment Composition

Some aquatic plants depend on the sediments for required nutrients. The richness or sterility, the hardness and the texture of the sediments may determine the type and abundance of species that can survive in a location.

Silt was the predominant sediment in Mason Lake, its occurrence increased with increased depth (Table 3). The availability of mineral nutrients for plant growth is highest in sediments of intermediate density such as silt, making it favorable for plant growth (Barko and Smart 1986).

Sand sediments were commonly occurring, especially in the 1.5-5ft depth zone (Table 3). Sand and rock are high-density sediments.

All sediment types supported a high percentage of vegetation in Mason Lake.

Table 3. Composition of the Sediments in Mason Lake

		0-1.5ft Depth Zone	1.5-5ft Depth Zone	5-10ft Depth Zone	Overall
Soft Sediments	**Silt**	8%	19%	96%	39%
	Muck	3%	3%		2%
	Peat	3%			1%
Mixed Sediments	**Sand/Silt**	8%	19%		9%
	Rock/Silt	3%			1%
Hard Sediments	**Sand**	27%	54%	4%	29%
	Rock	35%			12%
	Gravel	8%			2%
	Rock/Sand	3%	3%		2%

Shoreline Land Use

Land use activities on shore can directly impact the plant community through increased sedimentation from erosion, increased nutrient input from fertilizer run-off and erosion and increased toxics from farm and urban run-off.

Cultivated lawn was the most frequently encountered land use at the shore and had the highest mean coverage (Table 4). Rip-rap and hard pavement were other disturbance land uses commonly encountered.

Native herbaceous cover, wooded cover and shrub cover were natural shorelines commonly encountered but none had a high mean coverage (Table 4).

Table 4. Shoreline Land Use, Mason Lake 2001

	Cover Type	Frequency of Occurrence at Transects	% Mean Coverage
Disturbed Shoreline	**Cultivated lawn**	**65%**	**51%**
	Rip-rap	**42%**	**3%**
	Hard Structure	**26%**	**3%**
	Pavement	**15%**	**1%**
	Eroded	**8%**	**1%**
Natural Shoreline	**Native Herbaceous**	**46%**	**18%**
	Wooded	**27%**	**15%**
	Shrub	**27%**	**8%**

Some type of disturbed shoreline covered 59% of the shore.

MACROPHYTE DATA

SPECIES PRESENT

A total of 36 different species of macrophytes were found during the 1988-2001 studies: 15 emergents species, 5 floating leaf species, and 16 submergent species (Table 5).

No endangered of threatened species were found.

Two non-native species were found:

Myriophyllum spicatum (Eurasian water milfoil)
Potamogeton crispus (curly-leaf pondweed)

Table 5. Mason Lake Aquatic Plant Species

Scientific Name	Common Name	I.D. Code
Emergent Species		
1) *Asclepias incarnata* L.	swamp milkweed	ascin
2) *Bidens connata* Muhl.	purplestem beggar-tick	bidco
3) *Carex* sp.	sedge	carsp
4) *Cornus sericeus* L.	red-osier dogwood	corse
5) *Decodon verticillatus* (L.) Elliott.	water willow	decve
6) *Echinochloa walteri* (Pursh) Heller.	wild millet	echwa
7) *Eleocharis palustris* L.	creeping spikerush	elepa
8) *Impatiens capensis* Meeb.	orange jewelweed	impca
9) *Iris versicolor* L.	northern blue flag	irive
10) *Phalaris arundinacea* L.	reed canary grass	phaar
11) *Polygonum amphibium* L.	water smartweed	polam
12) *Sagittaria latifolia* Willd.	common arrowhead	sagla
13) *Scirpus validus* Vahl.	softstem bulrush	sciva
14) *Sparganium eurycarpum* Engelm.	giant bur-reed	spaeu
15) *Typha angustifolia* L.	narrow-leaf cattail	typan
Floating leaf Species		
16) *Lemna minor* L.	small duckweed	lemmi
17) *Nuphar variegata* Durand.	bull-head pond lily	nupva
18) *Nymphaea odorata* Aiton.	white water lily	nymod
19) *Spirodela polyrhiza* (L.) Schleiden.	great duckweed	spipo
20) *Wolffia columbiana* Karsten.	common watermeal	wolco
Submergent Species		
21) *Ceratophyllum demersum* L.	coontail	cerde
22) *Chara* sp.	muskgrass	chasp
23) *Elodea canadensis* Michx.	common waterweed	eloca
24) *Myriophyllum sibiricum* Komarov.	common water milfoil	myrsi
25) *Myriophyllum spicatum* L.	Eurasian watermilfoil	myrsp
26) *Najas flexilis* (Willd.) Rostkov & Schmidt.	slender naiad	najfl
27) *Potamogeton amplifolius* Tuckerman.	large-leaf pondweed	potam
28) *Potamogeton crispus* L.	curly-leaf pondweed	potcr
29) *Potamogeton foliosus* Raf.	leafy pondweed	potfo
30) *Potamogeton nodosus* Poiret.	long-leaf pondweed	potno
31) *Potamogeton pectinatus* L.	sago pondweed	potpe
32) *Potamogeton praelongus* Wulf.	whitestem pondweed	potpr
33) *Potamogeton pusillus* L.	slender pondweed	potpu
34) *Potamogeton richardsonii*	clasping-leaf pondweed	potri
35) *Ranunculus longirostris* Gordon.	white water-crowfoot	ranlo
36) *Zosterella dubia* (Jacq.) Small.	water stargrass	zosdu

FREQUENCY OF OCCURRENCE

Ceratophyllum demersum (coontail) was the most frequent species in 1988 (Table 6).

Myriophyllum spicatum (Eurasian watermilfoil) became the most frequent species in 1992. Its frequency then declined dramatically in 1995, but had partially recovered in 1998.

When *M. spicatum* declined, *C. demersum* again became the most frequent species in 1995 and 1998 (Table 6).

Table 6. Frequencies of Prevalent Macrophyte in Mason Lake, 1988-1998.

Species	1988	1992	1995	1998(Aug)
Ceratophyllum demersum	**98%**	62%	**83%**	**98%**
Elodea canadensis		3%	6%	23%
Myriophyllum sibiricum	*	18%	13%	31%
Myriophyllum spicatum	*	**92%**	19%	65%
Najas flexilis	16%	36%	26%	24%
Potamogeton crispus	0%	22%	8%	24%
Potamogeton zosteriformis	0%	32%	0%	0%

* *Myriophyllum* species were not separated in the 1988 survey

The occurrence of filamentous algae was not recorded in 1988 or 1995. Its frequency was 23.7% in 1992 and 29.7% in August of 1998.

DENSITY

Ceratophyllum demersum (coontail) had the highest mean density in 1988. *Myriophyllum spicatum* (Eurasian watermilfoil) had the highest mean density in 1992 (Table 7). As the density of *M. spicatum* declined in 1992, *C. demersum* was again the species with the highest density in 1995 and 1998. The density of *M. spicatum* was increased again by 1998 (Table 7).

Table 7. Mean Densities of Prevalent Macrophyte in Mason Lake 1988-1998.

Species	1988	1992	1995	1998(Aug)
Ceratophyllum demersum	**3.9**	2.3	**2.8**	**5.2**
Myriophyllum sibiricum	*	0.4	0.3	0.9
Myriophyllum spicatum	*	**3.3**	0.5	2.1
Najas flexilis	0.3	1.1	0.4	0.6
Potamogeton crispus	0	0.5	0.1	0.6
Potamogeton pectinatus	0	0.5	0.3	0.3

* species of milfoil were not separated in the 1988 survey

DOMINANCE

Combining relative frequency and relative density into a Dominance Value indicates how dominant a species is in the community. *Ceratophyllum demersum* (coontail) was the dominant species in 1988. *Myriophyllum sibiricum* (Eurasian watermilfoil) became the dominant species in 1992 (Figure 3) and dominated all depth zones. When *M. sibiricum* declined, *C. demersum* was again the dominant species in 1995 and 1998 and dominant in all depth zones.

The larger portion that "other species" represent in the 1995 community suggests that species diversity was higher in 1995.

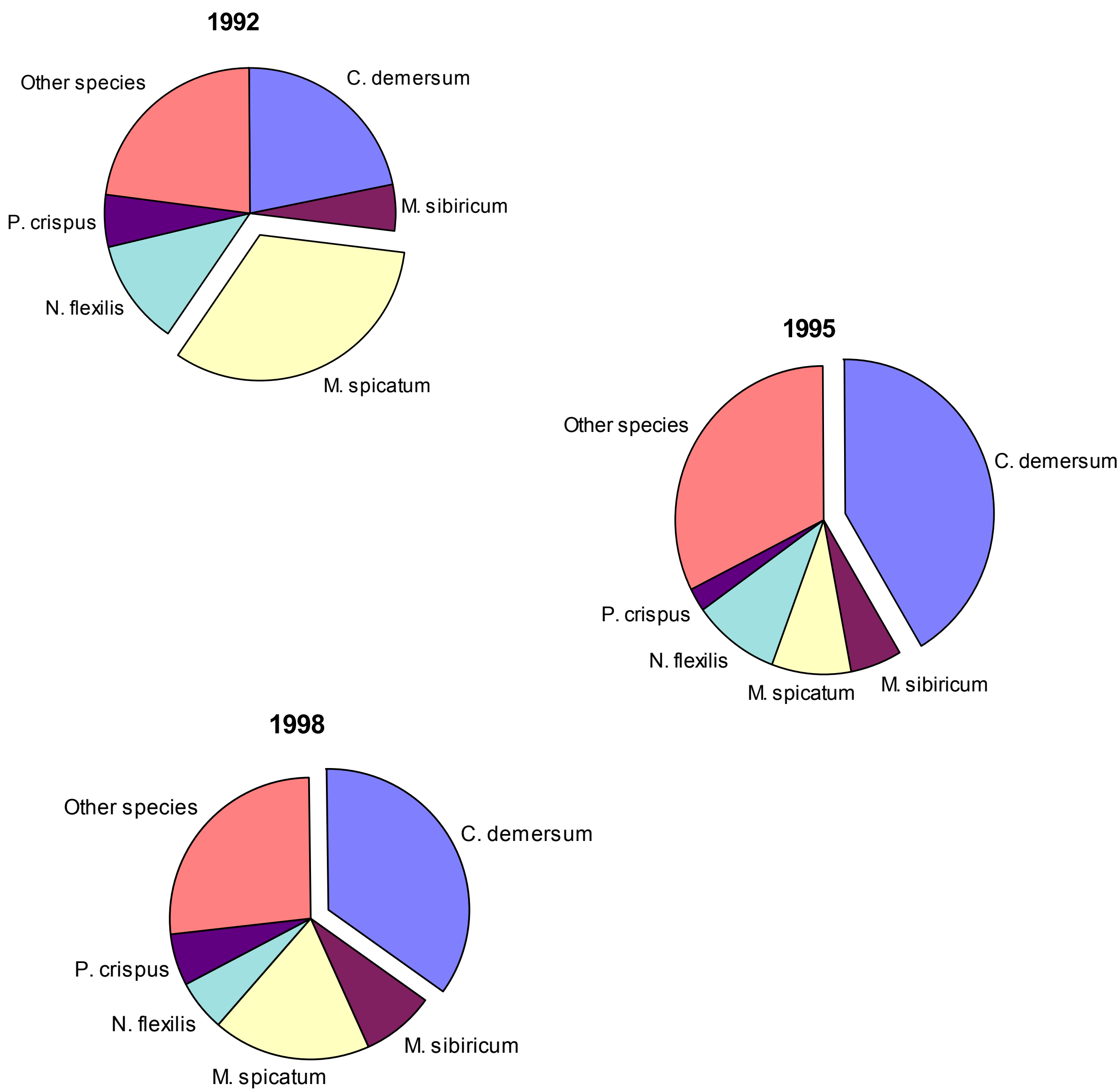


Figure 3. Dominance of prevalent species in Mason Lake, based on Dominance Value, 1988-1998.

DISTRIBUTION

Aquatic plants occur throughout Mason Lake. All of the sampling sites where vegetated in 1988, 1992 and 1998. In 1995, 88% of the sites in Mason Lake were vegetated.

81% of the sites in the 0-1.5ft depth zone
88% of the sites in the 1.5-5 ft. depth zone
100% of the sites in the 5-10 ft. depth zone.

The highest total occurrence and density of aquatic plant growth occurred in 1992 and 1998; the lowest total occurrence and density of plant growth occurred in 1995 (Figure 4, 5). The depth zone with the highest total occurrence and density of plants has changed from the 1.5-5 ft. depth zone to the 0-1.5 ft. depth zone.

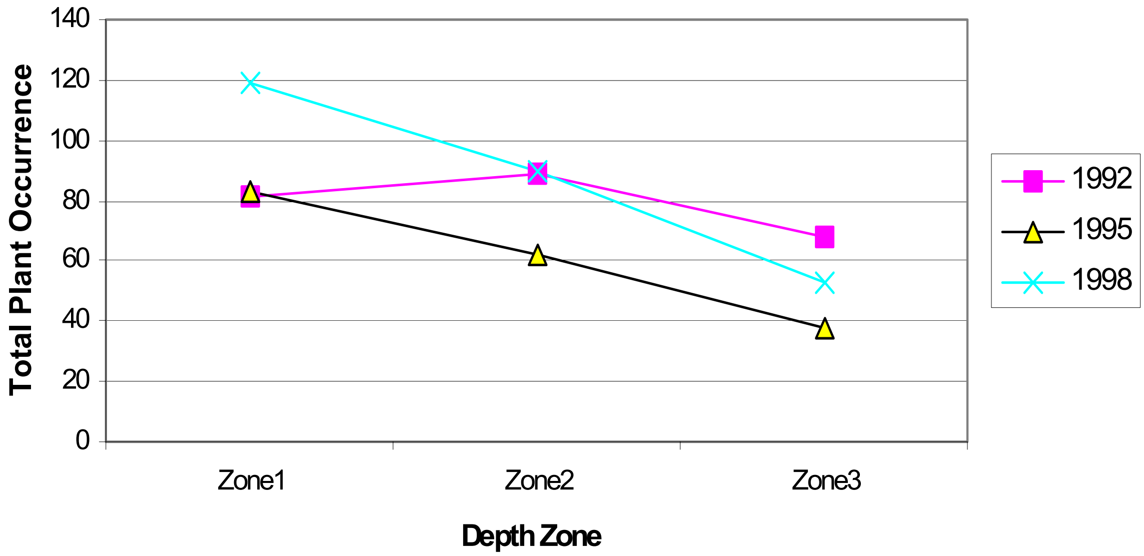


Figure 4. Total occurrence of macrophytes by depth zone, 1988-1998.

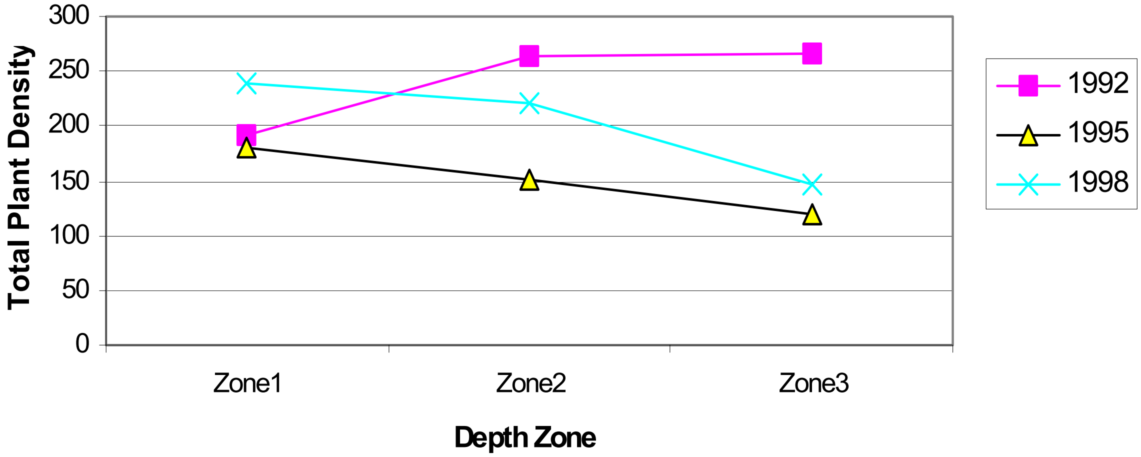


Figure 5. Total density of macrophytes by depth zone, 1988-1998.

MACROPHYTE COMMUNITY

The Coefficient of Community Similarity indicates the percent similarity between two communities; values less than 75% indicate that the two communities are significantly different. The Coefficients indicate that the plant community in Mason Lake has changed significantly.

In Mason Lake, the 1992 and 1995 aquatic macrophyte communities were only 57% similar.

The 1995 and 1998 communities were 71% similar (Table 8).

Because the differences between the plant communities of the 1992 and the 1998 were 66% similar, more similar than the 1992 and 1995, it appears there had been a change back toward the 1992 plant community (Table 8).

Table 8. Coefficients of Community Similarity.

	Coefficient	% Similarity
1992-1995	0.5707	57%
1995-1998	0.7127	71%
1992-1998	0.6559	66%

Several parameters can be used to characterize an aquatic plant community and measure what changes have occurred within the community that result in low Coefficients of Community Similarity (Table 9).

The number of species occurring at the sample sites increased 1992 to 1995 and then declined in 1998 (Table 9).

The maximum rooting depth and Simpson's Diversity Index has remained fairly stable. A Diversity index of 1.0 would mean that each individual in a community was a different species, the most diversity that could be found.

The percent of sites with emergent species has increased slightly (Table 9).

The percentage of littoral zone that was vegetated and the coverage of submerged vegetation both decreased in 1995 and increased again in 1998. The coverage of free-floating species has increased since 1992 (Table 9).

The Floristic Quality Indices suggest that disturbance in the plant community decreased in 1995 and increased again in 1998 (Table 9). The Floristic Quality measures the closeness of a plant community to an undisturbed community by measuring the occurrence of disturbance tolerant species. A decrease in Floristic Quality indicates an increase in disturbance.

Table 9. Changes in the Macrophyte Community.

	1992	**1995**	**1998 August**	**Maximum Change**	**%Change 1992-98**
Number of Species	16	27	20	11	25.0%
Maximum Rooting Depth	8.0	9.0	9.0	1	12.5%
% of Littoral Zone Vegetated	100%	88%	100%	0.1	0.0%
%Sites/Emergents	5%	8%	8%	0.0	60.0%
%Sites/Free-floating	62%	85%	97%	0.4	56.5%
%Sites/Submergents	99%	60%	86%	0.4	-13.1%
%Sites/Floating-leaf		1%		0.0	
Simpson's Diversity Index	0.84	0.84	0.86	0.02	2.4%
Floristic Quality	11.08	17.12	13.50	6.04	21.8%

An Aquatic Macrophyte Community Index (AMCI) developed for Wisconsin lakes (Weber et. al. 1995) was applied to Mason Lake. Several parameters that characterize the aquatic macrophyte community (Table 10) are measured and the data for each is converted to a value 0 - 10 as outlined by Weber et. al. (1995). The maximum AMCI value is 60 and the average AMCI value for Wisconsin lakes is 40. According to the AMCI value, the aquatic community in Mason Lake is of below average quality (Table 10). Though still below average, the quality was highest in 1995.

Table 10. Aquatic Macrophyte Community Index Values for Mason Lake, 1988-1998.

	1988	1992	1995	1998
Maximum Rooting Depth	4	4	4	4
% Littoral Zone Vegetated	10	10	10	10
Simpson's Diversity Index	7	8	9	9
Relative Frequency of Submersed Species	7	8	6	7
Relative Frequency of Sensitive Species	0	0	0	0
# of Taxa (reduced by exotic)	2	2	4	2
Total	30	32	33	32

Changes in the plant community are seen when there has been changes in the individual species within the community. Many species have changed in frequency and density in Mason Lake during the study years (Appendix XXVII).

The frequency and density of *Ceratophyllum demersum, Elodea canadensis, Lemna minor, Potamogeton praelongus, Spirodela polyrhiza, Wolffia columbiana* and *Zosterella dubia* have increased steadily since 1992 with *E. canadensis* showing the largest increase (770-1200% increase).

Najas flexilis and *Typha angustifolia* have steadily decreased in frequency and density; *Nitella, Potamogeton zosteriformis, Sagittaria latifolia, Scirpus validus* appear to have disappeared from the Mason Lake plant community.

Myriophyllum sibiricum, M. spicatum, Potamogeton crispus, P. pectinatus, Ranunculus longirostris and *Sparganium eurycarpum* decreased in frequency and density from 1992 to 1995, but increased again in 1998. *M. spicatum* and *P. pectinatus* are still found at lower levels than 1992.

Chara, Nymphaea odorata, Potamogeton amplifolius, P. pusillus, P. foliosus and *P. nodosus* increased in frequency and density in 1995, but decreased in 1998. However, *P. pusillus* has a higher frequency and density than it did in 1992.

IV. IMPACT OF DRAWDOWN VS. CHEMICAL TREATMENTS

The Coefficients of Community Similarity indicate that there was significant change in the plant community in Mason Lake from 1998 to 1999, before and after the two control methods.

In the drawdown zone, the plant communities were significantly different after the drawdown; the June plant communities before and after were 74% similar and the August communities were 70% similar (Table 11).

In the herbicide-treated zone, the June communities before and after treatment were not significantly different (82% similar), but the
August communities were significantly different, only 66% similar.

Table 11. Coefficients of Community Similarity

	Drawdown Impact	Herbicide Impact
June Communities	0.740	0.822
August Communities	0.7005	0.657

The herbicide treatment did not appear to have an impact on the June community, but appeared to have the most impact on the August community (Table 11). Winter drawdown appeared to have a significant impact on both the June and August communities.

FREQUENCY OF OCCURRENCE

Winter Drawdown Impacted Zone

In June, after the drawdown, 11 species decreased in frequency, *Ceratophyllum demersum, Chara, Myriophyllum spicatum* and *Najas flexilis* decreasing noticeable. Five species increased in frequency, *Myriophyllum sibiricum, Potamogeton crispus* and *P. pusillus* increasing noticeable (Figure 6).

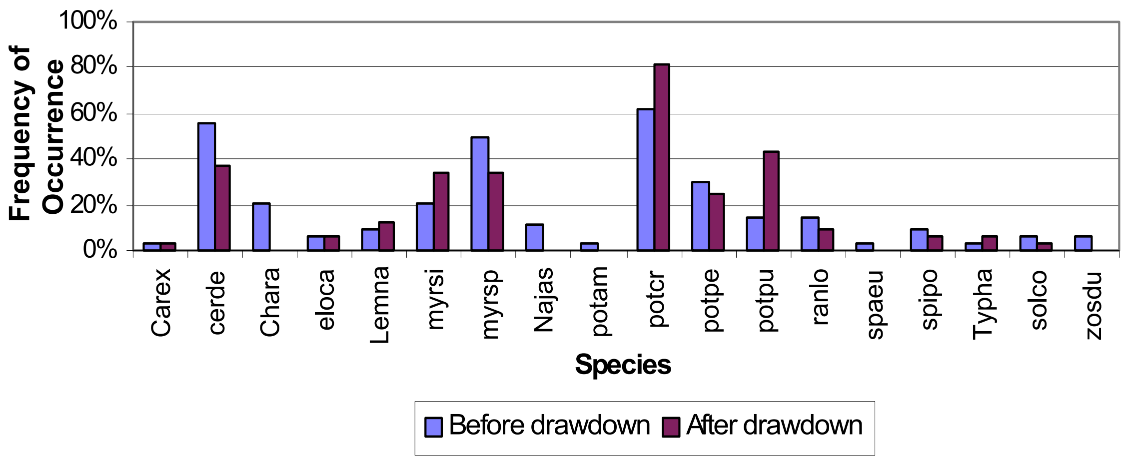


Figure 6. Change in frequencies of aquatic macrophytes in Mason Lake, June 1998-1999 in the drawdown zone.

By August of the same year, 17 species were found at decreased frequencies as compared to pre-drawdown, *Elodea canadensis, Najas flexilis, Potamogeton crispus, P. pusillus, Ranunculus longirostris, Zosterella dubia,* both milfoils and the three duckweed species noticeably decreased (Figure 7).

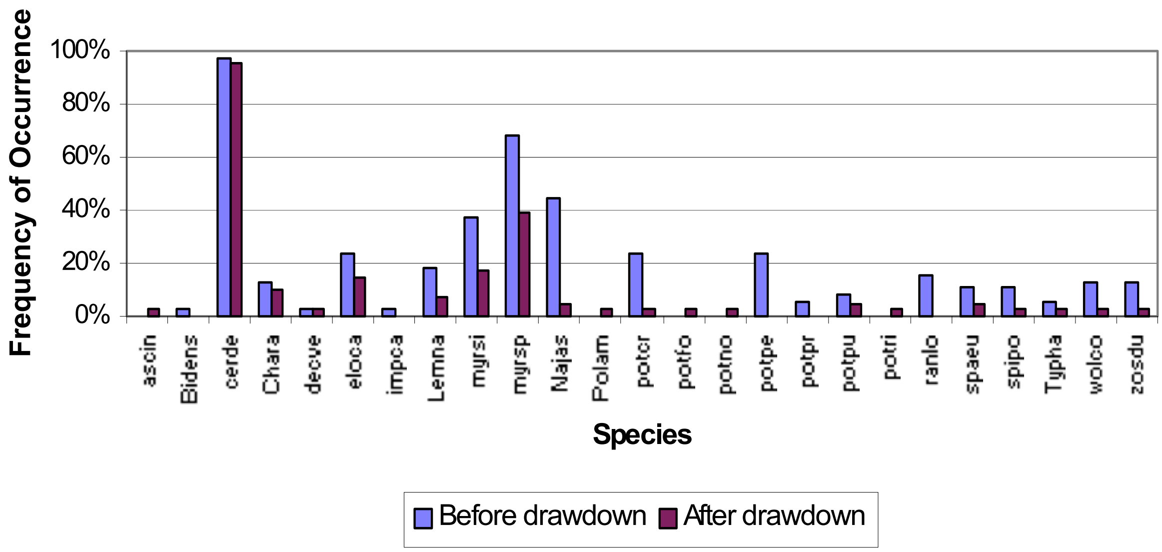


Figure 7. Change in frequencies of aquatic macrophytes in Mason Lake, August 1998-1999 in drawdown zone.

Selective Chemical Treatment Impacted Zone

In August, after the selective treatment, 9 species disappeared or decreased in frequency: *Chara, Elodea canadensis, Potamogeton amplifoilius, P. crispus, Myriophyllum spicatum* and *Nuphar variegata* (Figure 8). *Ceratophyllum demersum* was found at an increased frequency.

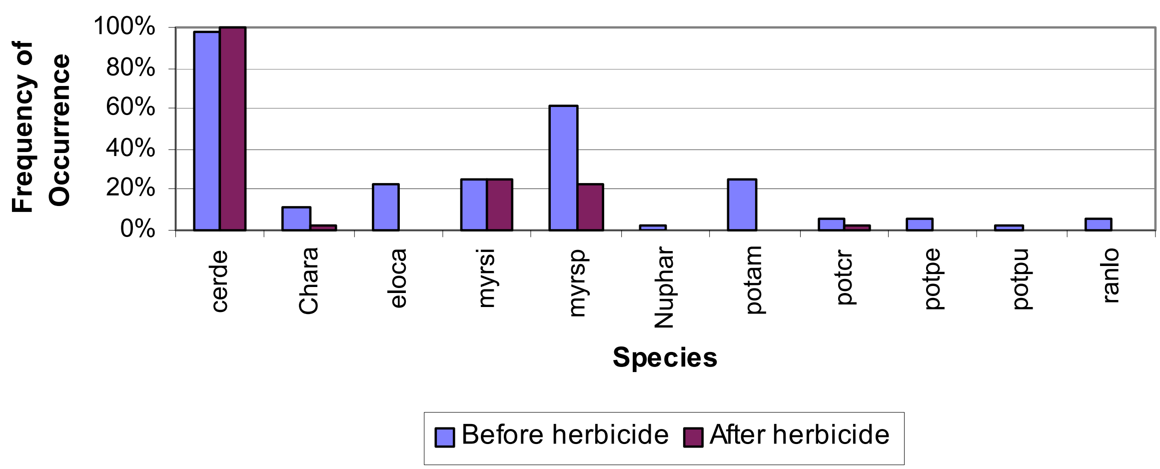


Figure 8. Change in frequencies of aquatic macrophytes in Mason Lake, August 1998-1999 in chemical treatment zone.

DENSITY

Winter Drawdown Impacted Zone

After the drawdown, the change in density of the aquatic plant species was very similar to the change in frequency, except for *Potamogeton crispus.* Even though the frequency of *P. crispus* increased post-drawdown, its density of growth decreased (Figure 9, 10).

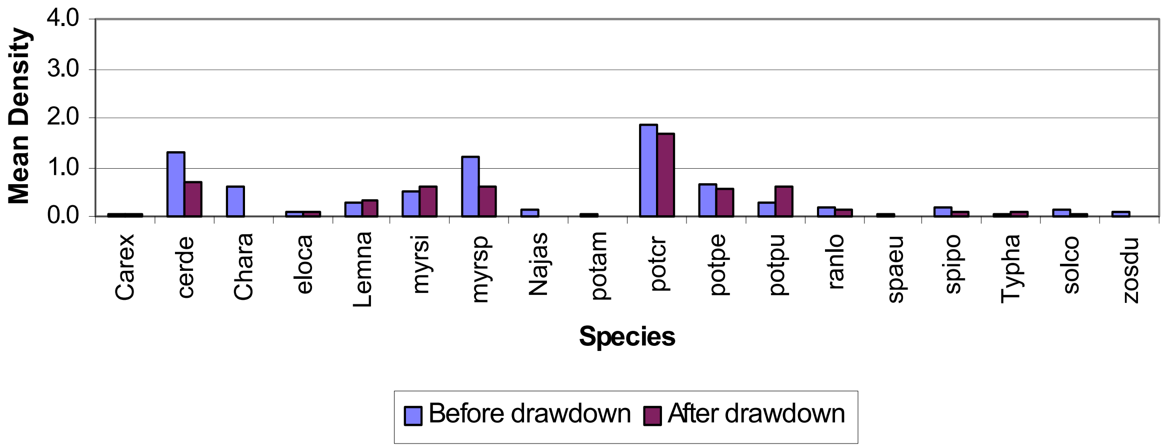


Figure 9. Change in density of aquatic macrophytes in Mason Lake, June 1998-1999 in drawdown zone.

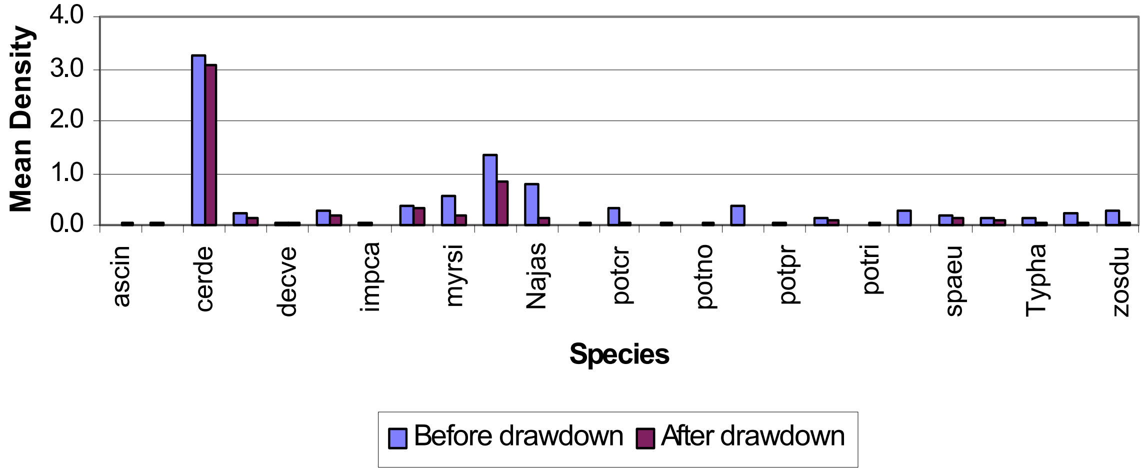


Figure 10. Change in density of aquatic macrophytes in Mason Lake, August 1998-1999 in drawdown zone.

Selective Chemical Treatment Impacted Zone

After the selective treatment, the change in density of aquatic plants followed the same pattern as the change in frequency, except: the density of the milfoils and *Ranunculus longirostiris* in June was decreased slightly as opposed to the increase in frequency (Figure 11).

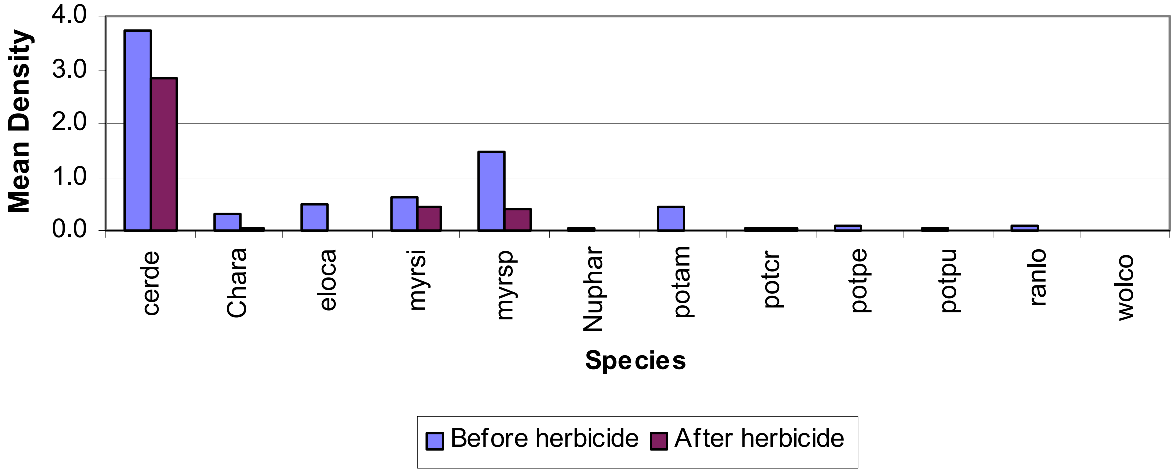


Figure 11. Change in density of aquatic macrophytes in Mason Lake, August 1998-1999 in chemical treatment zone.

DISTRIBUTION

The total occurrence and density of aquatic plants decreased post-drawdown, especially in August in the 0-1.5ft depth zone (Figure 12, 13).

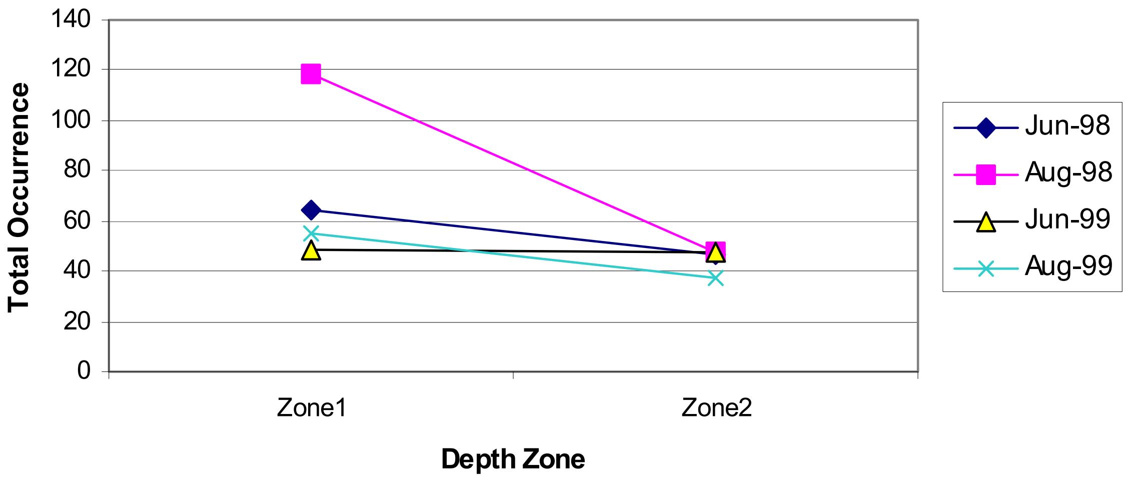


Figure 12. Total occurrence of macrophytes pre- and post-drawdown, 1998-1999.

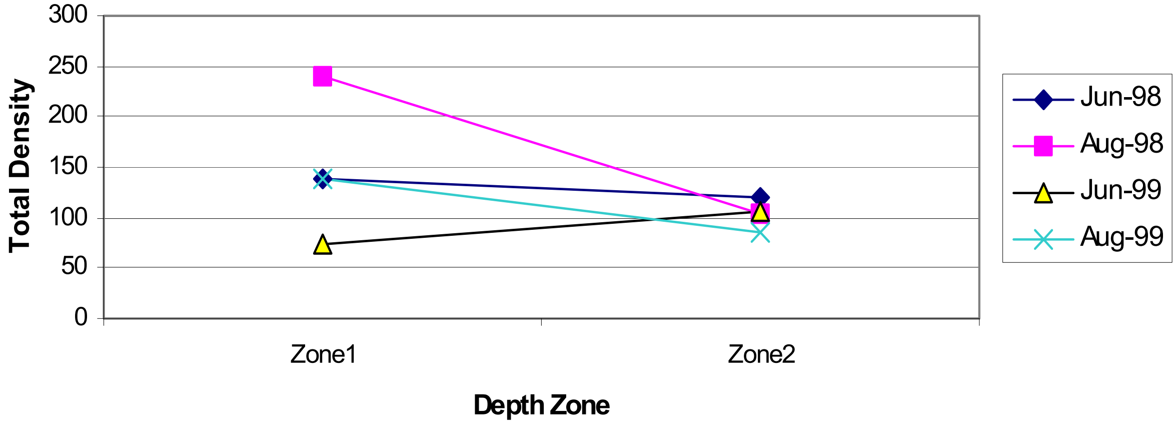


Figure 13. Total density of macrophytes pre- and post-drawdown, 1998-99.

The total occurrence and density of plants in the herbicide treatment zone increased in the June community and decreased in the August community (Figure 14, 15).

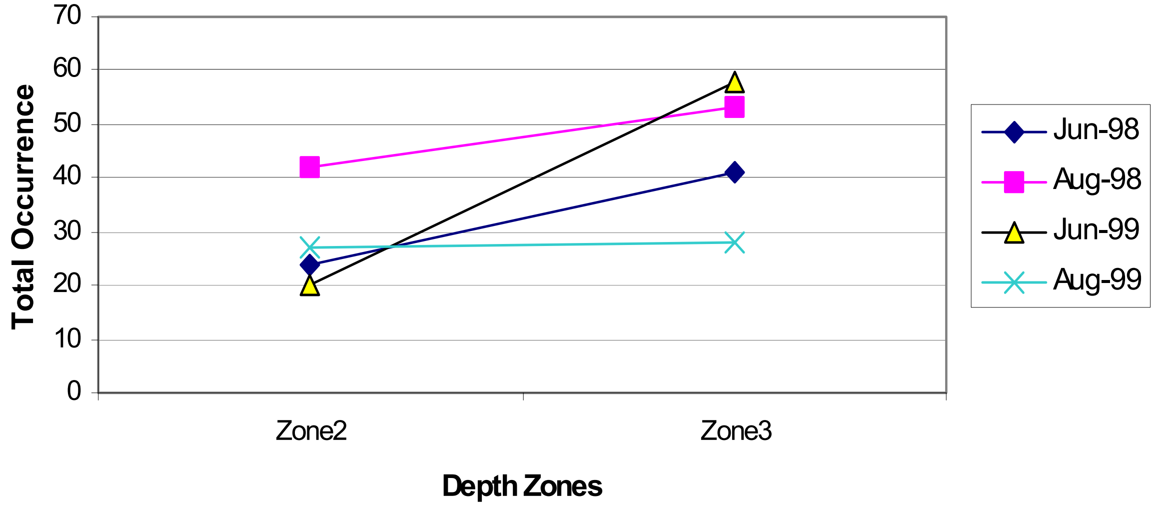


Figure 14. Total occurrence of macrophytes before and after treatment, 1988-1998.

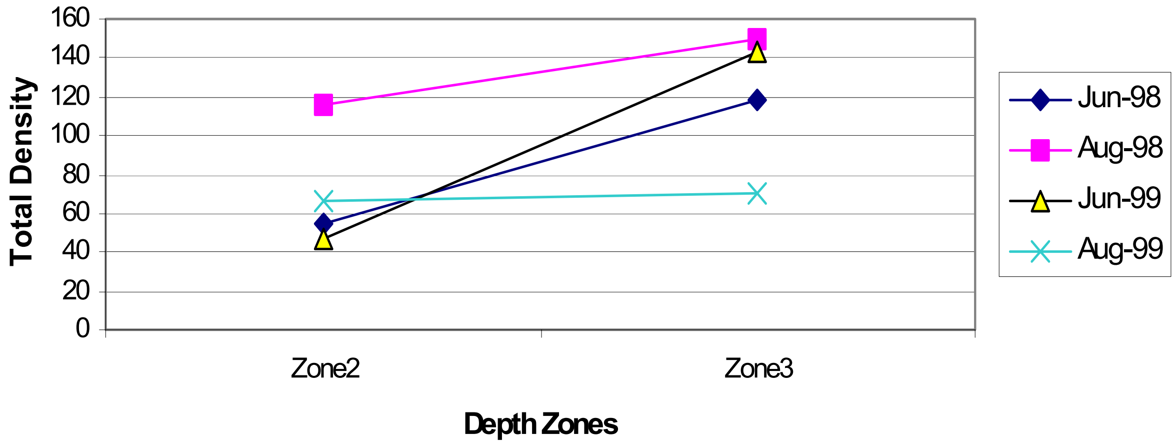


Figure 15. Total density of macrophytes before and after treatment, 1988-1998.

MACROPHYTE COMMUNITY

The number of species occurring at the sample sites remained the same in the drawdown zone, but decreased 23% in the herbicide treatment zone (Table 12, 13).

The percentage of the littoral zone that is vegetated increased 3% in the drawdown zone, but remained the same in the herbicide treatment zone (Table 12, 13).

The percent of sites with free-floating species and submergent species decreased 11% and 22% in the drawdwon zone and 3% and 33% in the herbicide zone (Table 12, 13).

Species diversity as measured by Simpson's Diversity Index decreased 3% and 14% in the June and August plant communities in the drawdown zone. Diversity decreased 31% in the August plant community in the herbicide zone (Table 12, 13).

In the drawdown zone, disturbance increased 7-41%. In the herbicide zone, disturbance increased 5-11% (Table 12, 13) as measured by Floristic Quality. The Floristic Quality measures the closeness of a plant community to an undisturbed community, so a decrease in Floristic Quality indicates an increase in disturbance.

Table 12. Changes in the Macrophyte Community Before and After Drawdown.

	1998	1999	Change 1998-99	%Change 1998-99
Number of Species	23	23	0	0.0%
% of Littoral Zone Vegetated	96	99	3	3.1%
%Sites/Emergents	15	8	-7.0	-46.7%
%Sites/Free-floating	80	71	-9.0	-11.3%
%Sites/Submergents	93	73	-20.0	-21.5%
%Sites/Floating-leaf			0.0	
Simpson's Diversity Index - June	0.89	0.86	-0.03	-3.4%
Simpson's Diversity Index - August	0.89	0.77	-0.12	-13.5%
Floristic Quality - June	17.40	10.25	-7.15	-41.1%
Floristic Quality - August	14.55	13.49	-1.06	-7.3%

Table 13. Changes in the Macrophyte Community Before and After Chemical Treatment.

	1998	1999	Change 1998-99	%Change 1998-99
Number of Species	13	10	-3	-23.1%
% of Littoral Zone Vegetated	100	100	0	0.0%
%Sites/Emergents			0.0	
%Sites/Free-floating	93	90	-3.0	-3.2%
%Sites/Submergents	93	62	-31.0	-33.3%
%Sites/Floating-leaf	2.0		-2.0	-100.0%
Simpson's Diversity Index - June	0.83	0.86	0.03	4.0%
Simpson's Diversity Index - August	0.78	0.54	-0.24	-30.8%
Floristic Quality - June	9.56	9.08	-0.48	-5.0%
Floristic Quality - August	9.29	8.28	-1.01	-10.9%

There were changes in the frequency and density of individual species with the two control methods.

In the drawdown zone,

1) The non-native species both decreased. *Myriophyllum*

spicatum decreased 32-50% in frequency and density. *Potamogeton crispus* decreased 15-94% in frequency and density.

2) *Ceratophyllum demersum* decreased 2-45% in frequency and density with the largest decrease in June.
3) *Elodea canadensis* decreased 38-41% in frequency and density.
4) One of the duckweed species, *Wolffia columbiana,* experienced the greatest decrease 50-92% in frequency and density.
5) *Potamogeton amplifoilius* disappeared after the drawdown.
6) 11 other species decreased.
7) Three native pondweeds increased.

In the herbicide treatment zone,

1) Six submerged species disappeared after the chemical treatment.
2) One non-native species decreased and the other increased. *Myriophyllum spicatum* decreased 19-70% in frequency and density. *Potamogeton crispus* increased 33-52% in frequency and density in June.
3) *Potamogeton pectinatus* and *Chara* experienced the greatest decrease (15-25% in frequency and density).
4) *Potamogeton pusillus* increased in the June community, but disappeared in the August community

V. CHANGE DURING THE SEASON

As expected, *Potamogeton crispus* (curly-leaf pondweed) occurred at a dramatically higher frequency in June than August. The frequencies of *P. crispus* in June 1998 and 2001 were comparable (Table 14).

Ceratophyllum demersum appears to have increased in frequency from June to August (Table 14).

Myriophyllum spicatum appears to start its growth early also, as the June and August frequencies in 1998 were similar. The frequency of *M. spicatum* in June increased from 1998-2001.

Myriophyllum sibiricum increased in frequency over the summer and also increased in frequency from 1998-2001 (Table 14).

Table 14. Frequencies of early-summer prevalent macrophytes in Mason Lake, 1988-2001.

Species	Aug. 1998	**June 1998**	**June 2001**
Ceratophyllum demersum	98%	**75%**	**41%**
Myriophyllum sibiricum	31%	**18%**	**31%**
Myriophyllum spicatum	65%	**66%**	**78%**
Potamogeton crispus	24%	**73%**	**78%**

Filamentous algae was found at 50.7% in June of 1998 and 48.7% of the sites in June 2001.
In 2001:

46% of the sites in the 0-1.5ft depth zone
69% of the sites in the 1.5-5ft depth zone
28% of the sites in the 5-10ft depth zone

The densities of *Ceratophyllum demersum* and *Myriophyllum sibiricum* were lower in June than August and lower in 2001 than in 1998. The density of *Potamogeton crispus* and *M. spicatum* was higher in June than August, and higher in 2001 than 1998 (Table 15).

Table 15. Mean Density of early-summer prevalent macrophytes in Mason Lake 1988-2001.

Species	Aug. 1998	**June 1998**	**June 2001**
Ceratophyllum demersum	3.45	**1.82**	**0.75**
Myriophyllum sibiricum	0.58	**0.48**	**0.42**
Myriophyllum spicatum	1.41	**1.79**	**2.46**
Potamogeton crispus	0.38	**2.00**	**2.09**

The early summer plant community appears to have three co-dominant species, based on Dominance Values. *Potamogeton crispus* (curly-leaf pondweed) and *Myriophyllum spicatum* (Eurasian watermilfoil) are non-native species, which start growth earlier than the native species. These species were co-dominant with *Ceratophyllum demersum* (coontail) (Figure 16). *P. crispus* declined in dominance from June to August, *M. spicatum* maintained its dominance, and *C. demersum* increased in dominance from June to August.

From June of 1998 to June of 2001, the dominance of *Potamogeton crispus* appears to have remained stable, *Myriophyllum spicatum* appears to have increased in dominance and *Ceratophyllum demersum* has decreased in dominance (Figure 16).

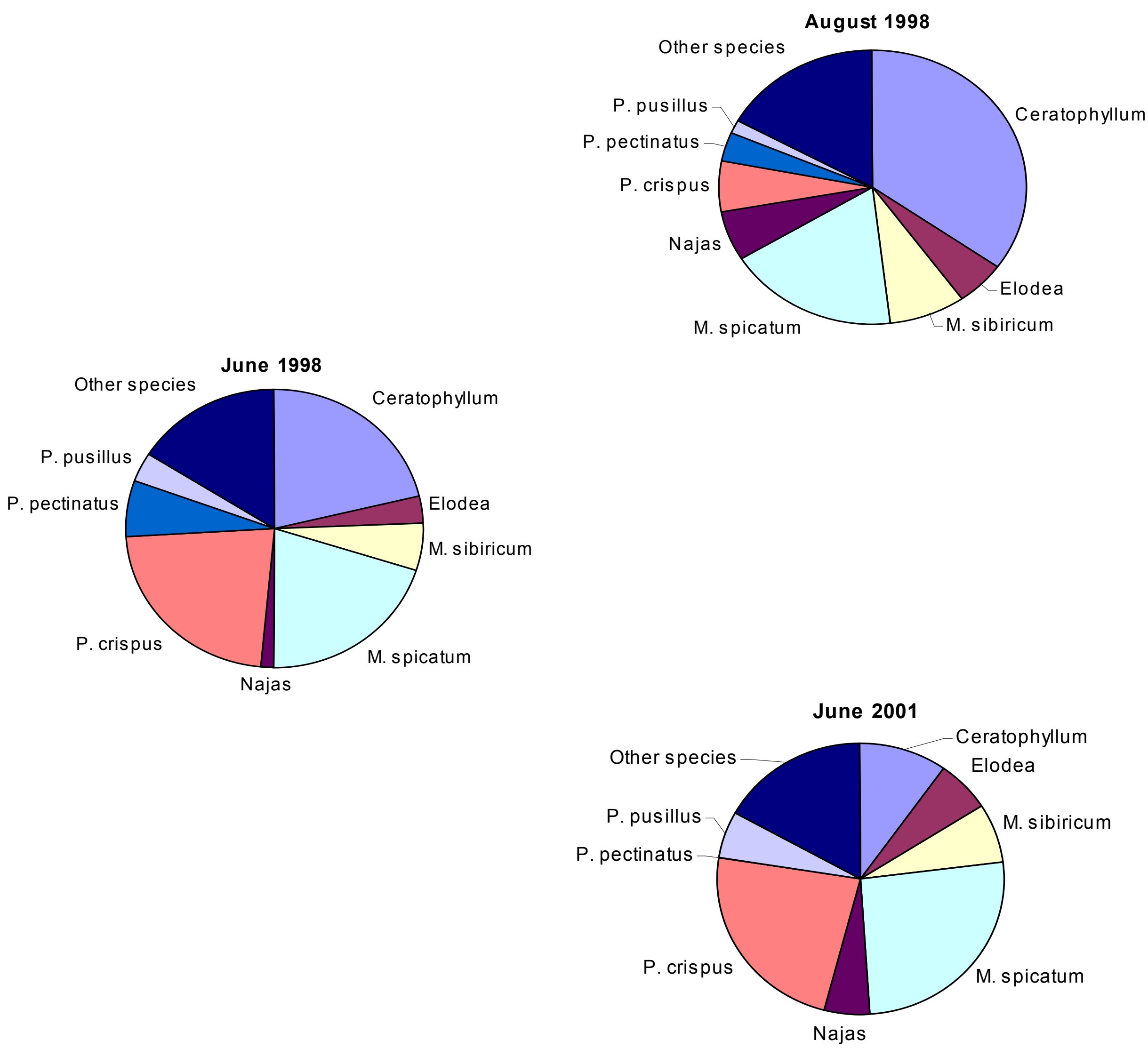


Figure 16. Change in the dominance of prevalent species from June to August in Mason Lake.

VI. DISCUSSION

Based on water clarity and the concentrations of algae and nutrients, Mason Lake was a eutrophic lake with poor water quality and water clarity during the study period (1986-2001).

Since 1986, nutrients have increased and algae has decreased. Algae and nutrients were lowest in 1991-1993. Because the algae concentrations did not closely follow the changes in the nutrient concentrations, other factors may be influencing the algae growth. These factors could include water temperature, rainfall patterns and/or decaying vegetation.

The majority of the shoreline on Mason lake is disturbed (cultivated lawn, rip-rap and hard structures). Disturbed shoreline occurred at more than half of the sites and covered approximately 59% or the shoreline. Cultivated lawn was predominant and rip-rap and hard structures were commonly encountered. These types of disturbed shoreline can result in degraded water quality through increased run-off carrying added nutrients from lawn chemicals, soil erosion and pet waste.

The aquatic plant community in Mason Lake is characterized by abundant growth, average species diversity and below average quality. The maximum rooting depth is equal to the maximum depth of Mason Lake. This means that there is a potential for plant growth to colonize the entire basin. Plant growth in Mason Lake is favored by the abundant nutrients of its trophic state, hard water, predominance of favorable silt sediments, the shallow depth of the lake and the gradually sloped littoral zone.

Poor water clarity may be impacting the aquatic plant community in Mason Lake. Indications that water clarity is impacting the plant community are:

1) Five of the six species that have increased since 1992 are tolerant of poor water clarity. This includes the free-floating species: (coontail, lesser duckweed, greater duckweed and watermeal).
2) Three of the six species that have disappeared or decreased are not tolerant of poor water clarity.

Ceratophyllum demersum (coontail) was the dominant species during all plant surveys, 1988-2001, except in 1992. *Myriophyllum spicatum* (Eurasian watermilfoil), an aggressive non-native species, was the dominant species in 1992.

Coontail and Eurasian watermilfoil can be limiting for habitat; when they occurs as dense mats, fish movement is hindered. The two exotic species (Eurasian watermilfoil and curly-leaf pondweed) can limit the quality of the habitat in the lake when they become too dominant. Dense plant beds of only exotic species does not provide a diverse habitat; this lack of diversity can not provide a variety of microhabitats to accommodate a variety of insect, fish and wildlife species. Curly-leaf pondweed adds an extra problem because it dies back early in the summer; this removes habitat and the decaying pondweed will provide nutrients for algae growth which reduces water clarity.

Two methods have been used in the past to manage the aquatic plant growth in Mason Lake:

Chemical treatments, 1972-82 and 1991-2001.

Chemicals have, over the years, been applied to almost the entire littoral zone and several channels across the lake.

The drawbacks of chemical treatments are:

1) they leave the plant material in the lake to decay, adding nutrients and fertile sediment for increased algae and plant growth
2) copper added to control the algae will build up in the sediment resulting in toxicity to portions of the aquatic food chain
3) broad-spectrum chemical used in 1972-2000 non-selectively killed all plant species, facilitating the spread of the exotic species
4) many invertebrates (food source for fish) are killed by aquatic herbicides

Winter drawdowns, 1988-1995 and 1998-2001

The winter drawdowns in Mason Lake were conducted by drawing the lake down 1.5-4ft to control drawdown sensitive species like Eurasian watermilfoil. Drawdowns of 1.5ft could provide control up to depths of 3ft; drawdowns of 4ft could potentially provide control up to depths of 5.5ft.

The drawbacks of winter drawdowns are

1) they are only somewhat selective, controlling all species that are sensitive to winter drawdown
2) only impact plant species up to a depth of about 3-5.5ft, depending on the depth of the drawdown

In spite of the drawback to winter drawdowns, some improvements were seen in the aquatic plant community in Mason Lake in 1995, after seven years of winter drawdown. All of these improvements were reversed in the 1998 aquatic plant community after three years of no winter drawdowns.

There was a significant difference in the plant community after seven years of drawdown. The Coefficients of Community Similarity measured a similarity of only 57% before and after drawdowns.

Improvement seen in Mason Lake in 1995 after seven years of drawdown:

1) There was decreased coverage of vegetation in the 0-5 ft. depth zone (in the zone impacted by drawdown).
2) There was decreased coverage of submerged plant growth.
3) There was decreased total occurrence and total density of plants in all depth zones.
4) The frequencies and densities of the two exotic, nuisance plants, Eurasian watermilfoil and curly-leaf pondweed were dramatically decreased and at their lowest in 1995.
5) The frequency and density of the two native species that have occurred at nuisance levels in Mason Lake, coontail

and sago pondweed, decreased.

6) There was an increase in aquatic plant species valuable for habitat: four pondweeds (including large-leaf pondweed) and lily pads.
7) There was increased aquatic plant species diversity. (Increased dominance of "other species" and increased number of species found in the survey.)
8) There was increased quality of the plant community as measured by the Aquatic Macrophyte Community Index (AMCI).
9) There was decreased disturbance. The Floristic Quality Index was highest in 1995, indicating the plant community was closest to an undisturbed condition. This suggests that the drawdowns were causing less disturbance to the plant community than the two non-native species.

All of these improvements were lost when the drawdowns were discontinued. Decreased vegetation is not always an improvement in a lakes ecosystem. Since plant coverage greater than 85% is not ideal for fish habitat, a decrease in vegetation can be an improvement in Mason Lake.

In 1998 and 1999, the impacts of winter drawdown was compared to the impacts of selective chemical treatments. Both winter drawdown and selective chemical treatments resulted in increased disturbance to the aquatic plant community (FQIndex).

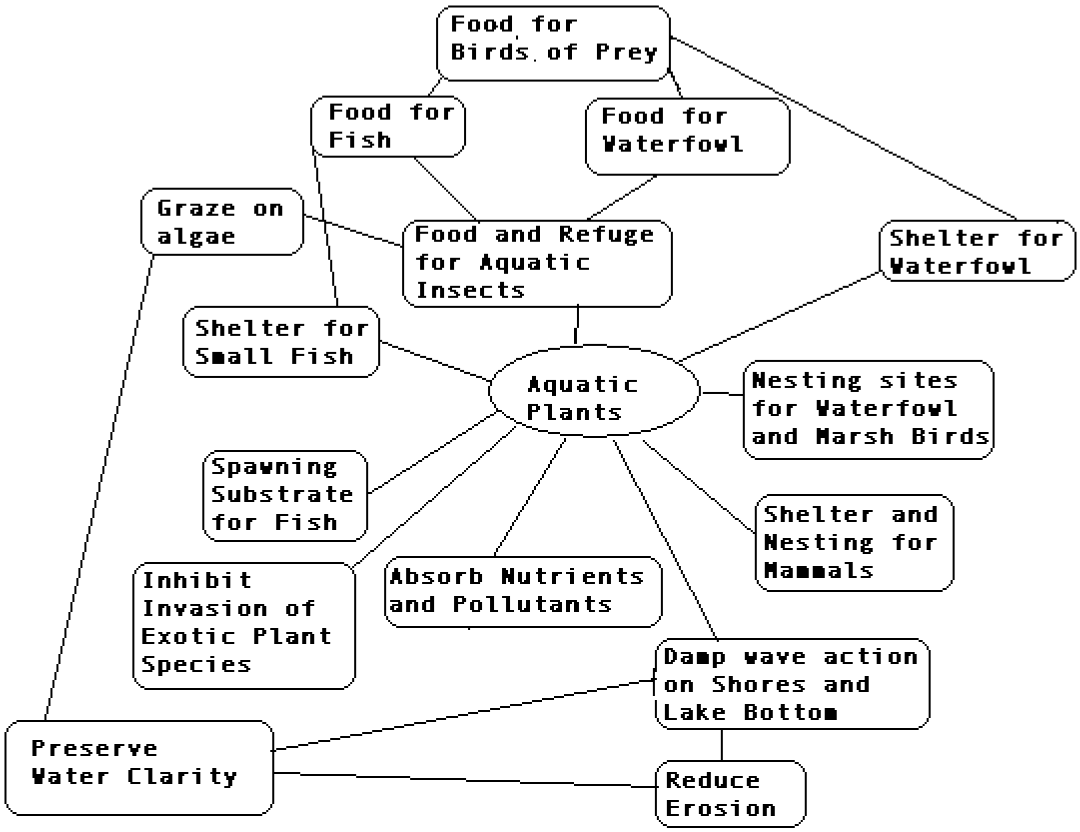
1) The winter drawdown resulted in a 3-14% decline in plant species diversity, but the selective chemical treatment resulted in a 30% decline in plant species diversity.
2) The winter drawdown resulted in a decrease in the two exotic species and the three duckweed species while the selective chemical treatment resulted in an increase of one of the exotic species (curly-leaf pondweed) and a decrease in the other exotic species (Eurasian watermilfoil).

Winter drawdowns were begun again in 1998. Since 1998, filamentous algae has decreased and the density and dominance of coontail has decreased.

VII. CONCLUSION

Benefits of the plant community

Aquatic plants are the cornerstones of the aquatic habitat and lake ecosystem. Aquatic plants in a lake are <u>the</u> habitat for fish and wildlife.



1) Plants start the food chain that all other life uses.
2) Plant beds provide shelter, cover, spawning and nesting areas for fish, waterfowl and other aquatic animals.
3) Plants produce the oxygen that other aquatic inhabitants need.
4) A healthy aquatic plant community can prevent an exotic plant species from becoming dominant in a lake.
5) Healthy plant communities (on shore and in the water) improve water quality in many ways:
   a) they trap nutrients, debris, and pollutants entering a water body;
   b) they can absorb and break down some pollutants;
   c) they reduce erosion by stabilizing banks, shorelines and lake bottoms and reducing wave action that resuspends sediments;
   d) they remove nutrients from the water that would otherwise be available for algae blooms (Engel 1985).

Aquatic Plants in Mason Lake

Mason Lake is a eutrophic lake with a plant community characterized by average diversity, low quality and abundant growth distributed throughout the entire lake basin.

Coontail and Eurasian watermilfoil have been the dominant species 1988-2001. Based on the June survey, the early summer plant community is dominated by curly-leaf pondweed, coontail and Eurasian watermilfoil. The curly-leaf pondweed dies off after it reaches its peak in June.

Coontail and Eurasian watermilfoil can be limiting for habitat; when they occurs as dense mats, fish movement is hindered. The two exotic species (Eurasian watermilfoil and curly-leaf pondweed) can limit the quality of the habitat in the lake when they become too dominant. Dense plant beds of only exotic species does not provide a diverse habitat; this lack of diversity can not provide a variety of microhabitats to accommodate a variety of insect, fish and wildlife species. Curly-leaf pondweed adds an extra problem because it dies back early in the summer; this removes habitat and the decaying pondweed will provide nutrients for algae growth which reduces water clarity.

The macrophytes in the Mason Lake provide nearly 100% cover at the sample sites, which is more than the ideal of 25-85% cover appropriate for a number of fish species.

Mason Lake will always be able to support abundant plant growth because of several factors that favor plant growth:

1) fertile sediments
2) hard water
3) more than adequate nutrients
4) broad, gradually sloped littoral zone
5) the shallow lake basin.

The only variable is what kind of plant growth it will support - a healthy native plant community - or - a community dominated by nuisance growth of non-natives - or - a community of dense algae.

Attempts to remove too much plant growth can switch a shallow like such as Mason Lake from a clear water, abundant plant phase to a turbid water, algae dominated, scarce plant phase. Once a shallow lake has switched, it is very difficult to switch back.

Aquatic Plant Management in Mason Lake

Two types of plant management have been conducted on Mason Lake: chemical treatments and winter drawdown. Studies suggest that both methods can adversely impact plant species diversity and increase disturbance within the plant community. However, studies suggest that the two exotic species can have a greater adverse impact on the plant community. During a period of seven years of winter drawdown the aquatic plant community changed significantly:

1) the water clarity improved

2) the nutrient and algae concentrations decreased
3) the two non-native species, Eurasian water milfoil and curly-leaf pondweed declined
4) a few native species that were growing to nuisance condition (coontail, sago pondweed, common waterweed) declined
5) the quality of the plant community increased
6) total area, frequency and density of plant growth declined
7) the diversity of plants increased
8) aquatic plant species that are valuable for habitat increased
9) disturbance measures decreased

When compared with selective chemical treatments, winter drawdown had a less severe impact on species diversity and was more successful in controlling both exotic species and opening up areas in the dense vegetation beds. However, winter drawdowns could not have an impact on vegetation in the deeper portions of the lake.

Recommendations to Mason Lake District for Aquatic Plant Management

A) **Continue winter drawdowns.** This method has been shown to reduce the two exotic plant species in the zone impacted by drawdown and reduce overall plant density to some extent.

B) **Do not return to broad spectrum chemical treatments.** The earlier chemical treatments that were not selective for the exotic nuisance-causing species were, ironically, promoting the spread of the nuisance-causing, exotic plant species. Those broad-spectrum chemical treatments could be compared to a newly plowed field; the weeds come back first. Future chemical treatments should be conducted to target the two non-native species: Eurasian watermilfoil and curly-leaf pondweed.

C) **Start a harvesting program**. This program should be designed to remove the curly-leaf pondweed early in the year before it dies back in late June and to reduce the coverage of Eurasian watermilfoil. Harvesting the curly-leaf will have short-term and long-term benefits.

a) Harvesting in May and early June has the potential to prevent the formation of the curly-leaf pondweed's turions, which are the source of the next year's curly leaf problem.
b) June harvesting will reduce the amount of curly-leaf decomposing in the lake, thus reducing nutrients released that feed summer algae blooms.
c) Harvesting through the summer will remove more nutrients in the plant biomass and may further lessen the severity of the algal blooms.
d) Harvesting and removing plant material will also reduce the amount of decaying plant material that use dissolved oxygen in the water, thus reducing the possibility of a fish kill due to low dissolved oxygen.

e) Cutting channels can modify the habitat by creating openings in the dense plant beds and increase the success of predatory fish, promoting a more balanced fish community.
f) Harvesting channels will immediately increase accessibility for fishing boats.

D) Establish a natural buffer zone of native vegetation around Mason Lake. There is too much cultivated lawn and hard surfaces at the shoreline and not enough natural area to absorb nutrients, pesticides or toxics. Protecting the shoreline will improve water quality and increase wildlife habitat.

E) Preserve and enhance wetlands in the around Mason Lake and in the watershed. The wetlands are acting as filters that clean the water before it enters the lake. They also regulate the water flow so that there are not drastic changes in the water level of the lake.

F) Cooperate with educational and other efforts in the watershed to reduce nutrient and toxic run-off.